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(54) Electromagnetic levitation type continuous metal casting apparatus

(57) A molten metal storing furnace (2) is connected by a supply tube structure (7) to a casting vessel (3) for upwardly receiving and holding molten metal in the form of a molten metal column and cooling means (4) is disposed on the outer periphery of the casting vessel (3) for cooling and solidifying the molten metal column. The molten metal column is upwardly moved by the effect of an alternating electromagnetic field provided by generation means (5) in the form of coils disposed on the outer periphery of the casting vessel (3). High frequency heating means (8) is disposed on the outer periphery of the molten metal supply tube structure (7) and the latter has at a bend section (7a) leading to the casting vessel an appendix section (7b) with associated high-frequency heating means (8a).

The levitation-producing coils (5a1, 5a2, Fig. 5) surround the casting vessel (3) to a lower level than the cooling means (4) and the latter provides a reverse-flow channel having a downward coolant flow direction nearest the casting vessel wall (3a) and a return flow channel nearest the generating means (5). The channels meet, (4a), in the zone of the coil (5a2) above the lowermost coil.

In another embodiment, (Figs. 6, 7 not shown), the horizontal tube of the supply tube structure is connected with the vessel (2) at a level higher than the normal molten metal level when the melt displacer (9) is in its withdrawn state.

FIG. 4

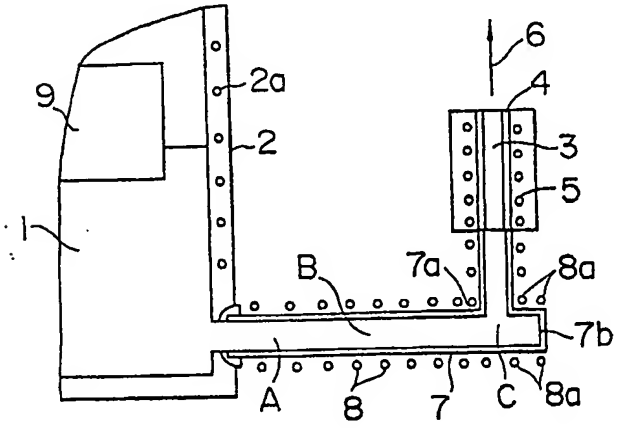

FIG. 5

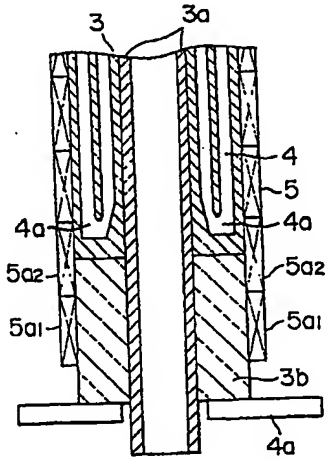

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FIG. 1
PRIOR ART

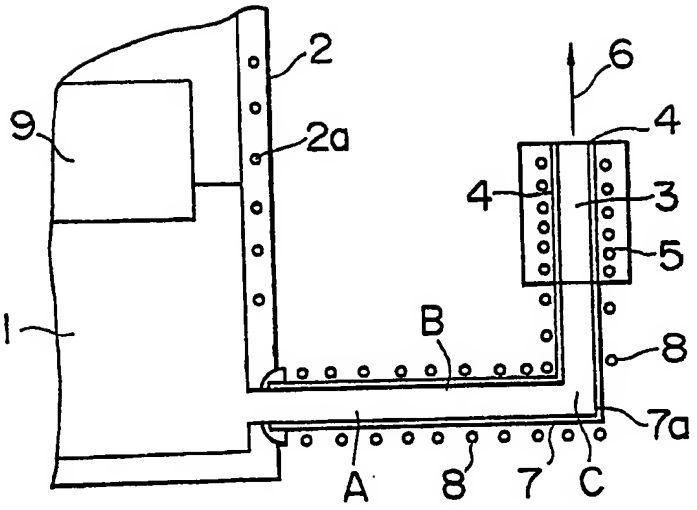


FIG. 2
PRIOR ART

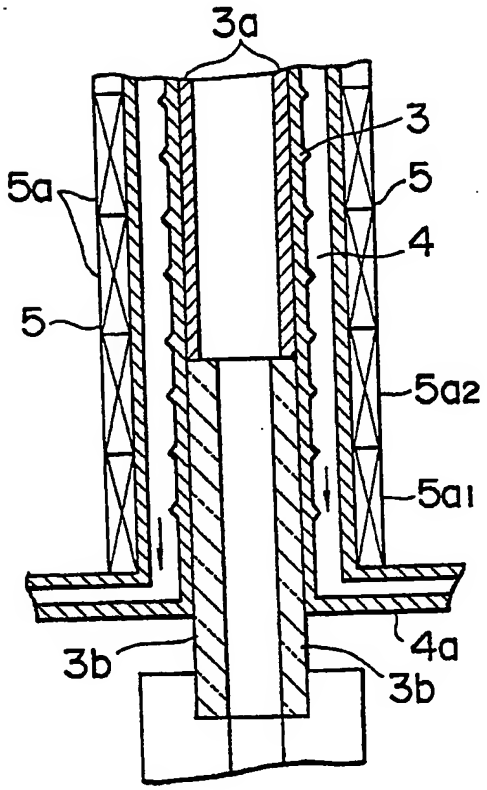


FIG. 3
PRIOR ART

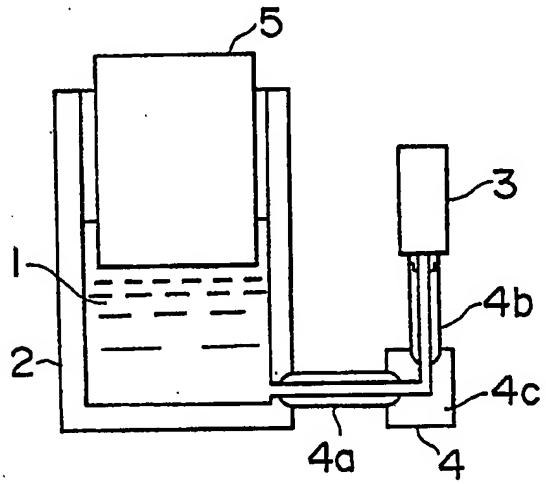


FIG. 4

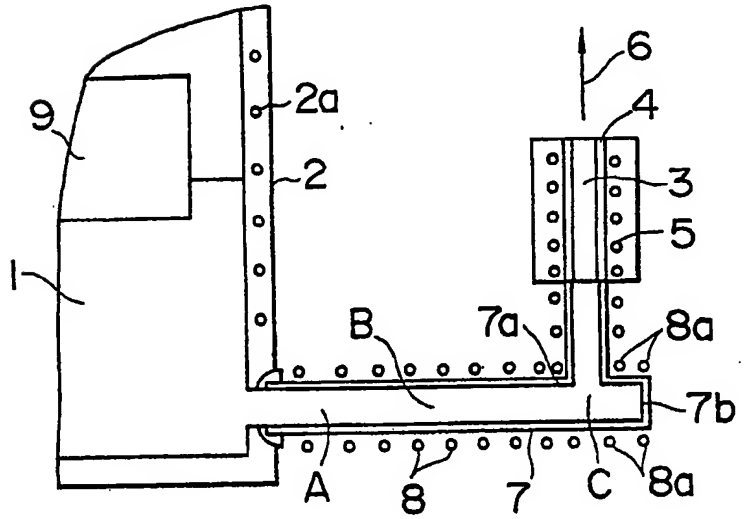


FIG. 5

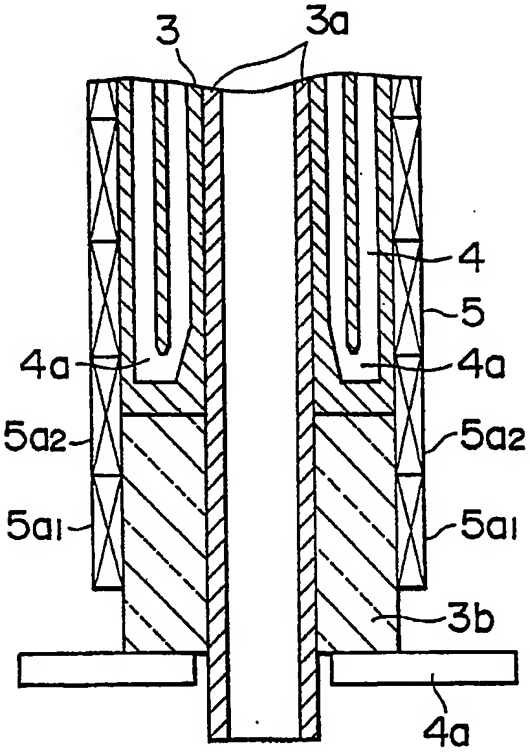


FIG. 6

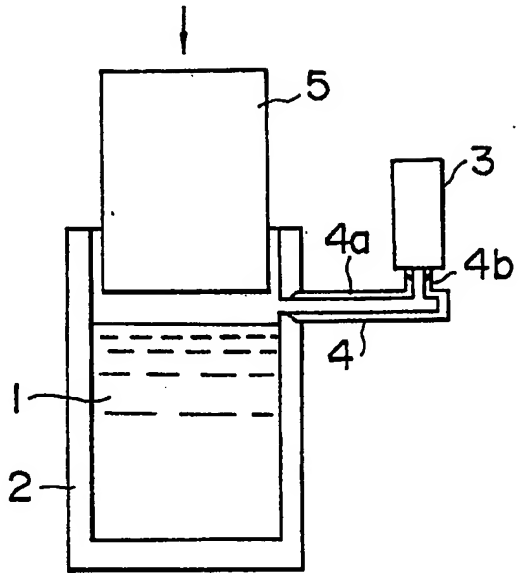
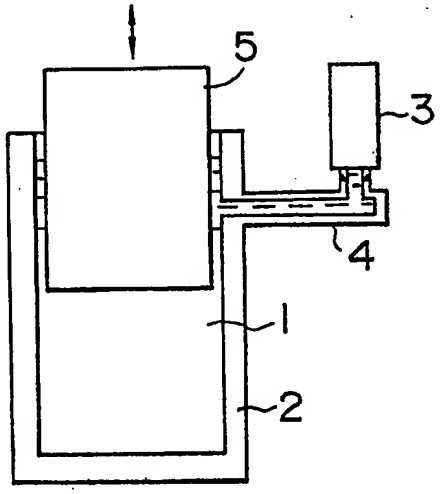


FIG. 7



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Electromagnetic levitation type continuous metal casting apparatus

The present invention relates to a modification of an electromagnetic levitation type continuous metal casting apparatus.

Conventionally, wires and rods composed of Al or Cu are produced by a continuous metal casting method as disclosed in US. Patent No. 4,414,285. In this method, molten metal in a column shape is upwardly supplied to an upper casting or forming area. Thereafter, the molten metal column is exposed to an alternating electromagnetic field and moved upwardly in the casting or forming area. Simultaneously, the molten metal column is successively cooled and solidified, and the solidified metal product thereafter is removed from the top of the casting or forming area. This electromagnetic levitation type continuous metal casting method has been practically used as an industrially effective means. According to the aforementioned electromagnetic levitation type continuous metal casting method, molten metal column to be cast or formed can be readily removed free from a frictional force and a bonding force against a casting vessel (mold) because the

aforementioned alternating electromagnetic field produces a gravity free state. In addition, in such a method, while the molten metal column passes through the alternating electromagnetic field, the inside of the molten metal column is stirred and thereby high homogeneity can be accomplished.

As an apparatus using the aforementioned continuous metal casting method as shown by a sectional view of FIG. 1 has been known. This apparatus comprises a molten metal storing furnace 2 for storing and holding a molten metal 1, a tube shaped casting vessel 3 vertically disposed for receiving the molten metal in the form of a column so as to solidify the molten metal 1, a heat exchange means 4 unified with the casting vessel 3 for cooling and solidifying the molten metal column received into the casting vessel 3, an alternating electromagnetic field generation means 5 composed of a plurality of layers of coils and disposed on almost all the periphery of the casting vessel 3 for generating the alternating electromagnetic field which upwardly moves the molten metal column, a means 6 for removing the solidified metal product which has been cooled and solidified from the top of the casting vessel 3, a molten metal supplying path 7 (named a rounder tube) for upwardly supplying the molten metal to be cast from the molten metal storing furnace 2 into the casting vessel 3, the molten metal supplying path 7 being a graphite tube with a high frequency heating means 8 disposed on the periphery thereof, and a liquid level adjusting unit 9 for adjusting the liquid level of the molten metal 1.

However, in the aforementioned electromagnetic levitation

type continuous metal casting method, there are following problems to be solved.

As one of the problems, since the molten metal supplying path 7 for upwardly supplying the molten metal 1 to be cast from the molten metal storing furnace 2 into the casting vessel 3 should successively supply the molten metal 1 with keeping it in a particular molten state, the graphite pipe with high conductivity is used and the high frequency heating means 8 is disposed on the periphery thereof. However, since the molten metal supplying path 7 is wound around the casting vessel 3 which is vertically disposed. At a bend section (elbow section) 7a, it is difficult to accomplish enough turns of a coil structuring the high frequency heating means 8. Thus, the molten metal 1 cannot be always kept in the particular molten state. In other words, when the molten metal is supplied at a relatively low speed so as to perform a low speed casting operation, since the molten metal being supplied is solidified or cooled at the bend section 7a, the required amount of the molten metal 1 cannot be continuously supplied. Thus, in the molten metal supplying path 7, an improvement of the apparatus for continuously supplying the molten metal 1 has been required.

As the second problem, in the electromagnetic levitation type continuous metal casting apparatus in the aforementioned structure, as shown in FIG. 2 which is an enlarged sectional view of the principal portions of the casting vessel of FIG. 1, the casting vessel 3, the heat exchange means 4, and the alternating electromagnetic field generation means 5 are

unified. In other words, on the outer periphery of the tube shaped casting vessel 3 with a fire proof layer 3a such as a graphite liner or the like disposed on the inner wall thereof, a flow path of a coolant (heat exchange means) is unified. In addition, in the full length of the outer periphery of the flow path of the coolant (heat exchange means) 4, a plurality of electromagnetic levitation coils (alternating electromagnetic field generation means) 5 are disposed. In such a structure, the first cooling point becomes a bottom plate 4a of the heat exchange means 4. When the alternating electromagnetic field generation means 5 is compose of six layers of coils 5a, required strength of the levitation electromagnetic field is obtained in the area of the second layer from both the ends thereof.

However, in the aforementioned electromagnetic levitation type continuous metal casting apparatus, there is the following problem. The molten metal column supplied upwardly from the molten metal storing furnace 2 for storing the molten metal 1 into the lower side of the casting vessel 3 through the molten metal supplying path 7 is cooled and solidified by the heat exchange means 4. At that time, the molten metal column is electromagnetically and upwardly moved by the alternating electromagnetic field generation means 5 and then desired cast products, such as, wires are continuously produced. Thus, breakouts of the wire often take place. Such breakouts result from the fact that part of molten metal column supplied upwardly to the casting vessel 3 is solidified in the area or the lower area of a coil 5a1 which is the first

layer from the bottom of the alternating electromagnetic field generation means 5, namely the area where levitating force and inwardly directed force cannot be satisfactorily obtained. Thus, the molten metal column is in contact with the wall of the casting vessel 3, thereby disturbing smooth upward movement of the molten metal column. To solve such a problem, in the wall area of the casting vessel 3 according to the coils 5a1 and the coil 5a2 which are respectively the first layer and the second layer from the bottom, a ceramic tube 3b is disposed, an air gap being disposed on the wall of the casting vessel 3 so as to decrease the thermal conductivity. However, in the aforementioned structure, the problem has not been solved.

The third problem is with respect to the molten metal supplying path. As shown in FIG. 3, an apparatus with a displacer 5 has been used, the displacer 5 pressing the molten metal 1 in the molten metal storing furnace 2 so as to supply the molten metal 1 in the molten metal storing furnace 2 to the casting vessel 3 through the molten metal supplying path 4. The molten metal supplying path 4 is connected to a side wall in the vicinity of the bottom of the molten metal storing furnace 2. The molten metal supplying path 4 is composed of a horizontal section 4a, a vertical section 4b, and connection section 4c for connecting them. In this case, the molten metal supplying path 4 for upwardly supplying the molten metal 1 to be cast from the molten metal storing furnace 2 into the casting vessel 3 is generally composed of a graphite tube with high thermal conductivity and a heating means using high

frequency heating method or the like, the heating means being disposed on the outer periphery of the graphite tube. The graphite tube structuring the molten metal supplying path 4 is oxidized and worn out by oxygen in the air or the molten metal 1. Namely, the durability of the graphite tube is low. Thus, since there are many joints between the horizontal section 4a and the molten metal storing furnace 2, between the horizontal section 4a and the vertical section 4c and between the vertical section 4b and the connection section 4c, the repair and replacement works become complicated. In addition, the possibility of leakage of the molten metal 1 increases. The possibility of the leakage of the molten metal at such joints is increased by the hydrostatic pressure by the molten metal 1 besides the required casting operation. In addition, in repairing and replacing the cooling means 4, the molten metal 1 in the molten metal storing furnace 2 should be removed or collected. It wastes the raw materials and increases the cost of the products. Therefore, an object of the present invention is to provide an electromagnetic levitation type continuous metal casting apparatus for decreasing or preventing the leakage of the molten metal 1 from the molten metal supplying path 4, the electromagnetic levitation type continuous metal casting apparatus being free of both the complicated repair and replacement works of the molten metal supplying path 4 and the discard and collection works of the molten metal 1 in the molten metal storing furnace 2.

The electromagnetic levitation continuous metal casting apparatus according to the first invention comprises a molten metal storing furnace for holding and storing a molten metal, a casting vessel for upwardly receiving and holding the molten metal in the form of a molten metal column, cooling means unified with the casting vessel and disposed on the outer periphery thereof for cooling and solidifying the molten metal column which is upwardly moved by the effect of an alternating electromagnetic field, alternating electromagnetic field generation means unified with the casting vessel and disposed on the outer periphery thereof for generating the alternating electromagnetic field, the alternating electromagnetic field electromagnetically and upwardly moving the molten metal column received and held in the casting vessel, a tube shaped molten metal supplying path for supplying the molten metal to be cast from the molten metal storing furnace to the casting vessel, and high frequency heating means disposed on the outer periphery of the tube shaped molten metal supplying path, wherein the tube shaped molten metal supplying path comprises a horizontal section extended from the molten metal storing furnace and a vertical section disposed for upwardly supplying the molten metal into the casting vessel through a bend section, the bend section being provided with an appendix section horizontally disposed on an opposite side of the molten metal storing furnace, the appendix section having high frequency heating means.

The electromagnetic levitation type continuous metal casting apparatus according to the second invention comprises

a molten metal storing furnace for holding and storing a molten metal, a casting vessel vertically disposed for upwardly receiving the molten metal in the form of a molten metal column, cooling means unified with the casting vessel and disposed on the outer periphery thereof for causing a coolant to flow in the opposite direction of the moving direction of the molten metal column and for cooling and solidifying the molten metal column, the molten metal column being upwardly moved by the effect of an alternating electromagnetic field, alternating electromagnetic field generation means unified with the casting vessel and disposed on the outer periphery thereof for generating the alternating electromagnetic field, the alternating electromagnetic field electromagnetically and upwardly moving the molten metal column received and held in the casting vessel, the alternating electromagnetic field generation means being composed of a plurality of electromagnetic coils disposed on the outer periphery of the casting vessel, a tube shaped molten metal supplying path for upwardly supplying the molten metal to be cast from the molten metal storing furnace into the casting vessel, and high frequency heating means disposed on the outer periphery of the tube shaped molten metal supplying path, wherein the cooling means for causing the coolant to flow in the opposite direction of the moving direction of the molten metal column is structured so that the flow of the coolant is inverted in an area according to the second electromagnetic coil from the lower end of the plurality of electromagnetic coils.

The electromagnetic levitation type continuous metal apparatus according to the third invention comprises a molten metal storing furnace for holding and storing a molten metal, a casting vessel vertically disposed for upwardly receiving and holding the molten metal in the form of a molten metal column, cooling means unified with the casting vessel and disposed on the outer periphery thereof for cooling and solidifying the molten metal column which is upwardly moved by the effect of an alternating electromagnetic field, alternating electromagnetic field generation means unified with the casting vessel and disposed on the outer periphery thereof for generating the alternating electromagnetic field, the alternating electromagnetic field electromagnetically and upwardly moving the molten metal column received and held in the casting vessel, a tube shaped molten metal supplying path for upwardly supplying molten metal to be cast from the molten metal storing furnace into the casting vessel, high frequency heating means disposed on the outer periphery of the tube shaped molten metal supplying path, and a displacer for pressuring the molten metal in the molten metal storing furnace and for supplying the molten metal into the casting furnace through the molten metal supplying path, wherein the molten metal supplying path is extruded substantially horizontally from a side wall of the molten metal storing furnace, the extruded position of the side wall being higher than the liquid surface of the molten metal when the displacer is raised from the molten metal in the molten metal storing furnace, and is directly connected to the casting vessel with

slight vertical section and without connection section.

FIG. 1 is a sectional view of the principal portions of a conventional electromagnetic levitation type continuous metal casting apparatus;

FIG. 2 is an enlarged sectional view of the principal portions of a casting vessel of the electromagnetic levitation type continuous metal casting apparatus shown in FIG. 1;

FIG. 3 is an outlined sectional view showing an apparatus for supplying a molten metal to be cast from a molten metal storing furnace provided with a displacer to a casting vessel through a molten metal supplying path in the structure of the principal portions of the conventional electromagnetic levitation type continuous metal casting apparatus;

FIG. 4 is a sectional view showing the structure of the principal portions of an electromagnetic levitation continuous metal casting apparatus according to an embodiment 1 of the present invention;

FIG. 5 is an enlarged sectional view showing the principal portions of the casting vessel according to an embodiment 2 of the present invention; and

FIGS. 6 and 7 are sectional views showing the structure of the principal portions of an electromagnetic levitation type continuous metal casting apparatus according to an embodiment 3 of the present invention.

Then, by referring to the accompanying drawings, preferred embodiments of the present invention will be described.

Embodiment 1

FIG. 4 is a sectional view showing the structure of the principal portions of an electromagnetic levitation type continuous metal casting apparatus according to the first invention. In the figure, the reference numeral 2 is the molten metal storing furnace for holding and storing the molten metal 1; the reference numeral 3 is the casting vessel for receiving and holding the molten metal 1 in the form of a molten metal column from the bottom thereof; the reference numeral 5 is the alternating electromagnetic field generation means unified with the casting vessel 3 and disposed on the outer periphery thereof for generating an electromagnetic field for electromagnetically and upwardly moving the molten metal column which is received and held in the casting vessel 3; the reference numeral 4 is the cooling means unified with the casting vessel 3 and disposed on the outer peripheral thereof for cooling and solidifying the molten metal column which is received and held in the casting vessel 3 and which is upwardly moved by the alternating electromagnetic field generation means 5, for example, the cooling means 4 is a cooling water path; the reference numeral 7 is the tube shaped molten metal supplying path for upwardly supplying the molten metal 1 to be cast from the molten metal storing furnace 2 into the casting vessel 3; and the reference numeral 8 is the high frequency heating means disposed on the outer periphery

of the molten metal supplying path 7. In the figure, the reference numeral 2a is a high frequency heating means for keeping the molten metal 1 stored in the molten metal storing furnace 2 in the molten state and the reference numeral 9 is a liquid surface adjusting member.

In the electromagnetic levitation type continuous metal casting apparatus according to the first invention, an appendix section 7b is provided with a high frequency heating means 8a at the bend section 7a upwardly extended to the molten metal supplying path 7. In other words, according to the present invention, the electromagnetic levitation type continuous metal casting apparatus is provided with the appendix section 7b having the high frequency heating means 8a at the bend section (elbow section) 7a of the molten metal supplying path 7 named a rounder tube for supplying the molten metal 1 to be cast from the molten metal storing furnace 2 to the casting vessel 3 named a levitator, the appendix section 7b being extended and unified therewith.

In the electromagnetic levitation type continuous metal casting apparatus, the tube shaped molten metal supplying path 7 and the appendix section 7b are made of a fire proof ceramic with electric conductivity. Examples of fire proof ceramics with electric conductivity are boron type ceramics such as TiB_2, ZrB_2, HfB_2, MoB_2, CrB_2, etc, nitride type ceramics such as TiN, ZrN, NbN, VN, etc, and carbide type ceramics such as ZrC, HfC, VC, TiC, etc. The extended length of the appendix section 7b is determined by considering the material, length, diameter, and so forth of the molten metal supplying path 7.

In other words, the extended length is set to the length where the high frequency coil 8a can be wound at the bend section 7a of the molten metal supplying path 7 so that the appendix section 7b can supply heat enough to prevent the molten metal 1 from being solidified.

A copper wire was continuously cast by using the electromagnetic levitation type continuous metal casting apparatus according to the present invention, the tube shaped molten metal supplying path 7 is composed of a graphite tube, the bend section 7a being provided with the appendix section 7b having the high frequency heating means 8a. TABLE 1 shows the result of measurement of temperatures of molten metal at points A and B of the molten metal supplying path 7 and point C of the bend section 7a shown in FIG. 4. In the table, the temperatures at points A and B of the molten metal supplying path 7 and point C of the bend section 7a of the conventional electromagnetic levitation type continuous metal casting apparatus (FIG. 1) are also shown so as to compare the temperatures between the electromagnetic levitation type continuous metal casting apparatus according to the present invention and the related art.

TABLE 1

	POINT A	POINT B	POINT C
EMBODIMENT	1121°C	1177°C	1161°C
PRIOR ART	-	1176°C	958°C

As shown in the above table, in the case of the

conventional electromagnetic levitation type continuous metal casting apparatus, the molten metal 1 supplied through the molten metal supplying path 7 is cooled at the bend section 7a of the molten metal supplying path 7 and thereby the flow of the molten metal 1 is stopped. On the other hand, in the case of the electromagnetic levitation type continuous metal casting apparatus according to the present invention, the molten metal 1 which is supplied through the molten metal supplying path 7 is kept at high temperature even at the bend section 7a of the molten metal supplying path 7 and thereby a high fluidity is obtained. In addition, when the molten metal supplying path 7 is made of a ceramic with electric conductivity, it is possible to prevent the molten metal 1 from being contaminated and the molten metal supplying path 7 from getting worn by the molten metal 1.

As was described above, according to the electromagnetic levitation type continuous metal casting apparatus of the present invention, in the molten metal supplying path 7 for supplying the molten metal 1 to be cast from the molten metal storing furnace 2 to the casting vessel 3, the temperature of the molten metal 1 can be maintained in the almost entire area of the molten metal supplying path 7. Thus, the molten metal 1 is smoothly supplied to the casting vessel 3 with nearly even fluidity in the entire area of the molten metal supplying path 7. Consequently, even when a wire material is continuously cast at low speed, high quality products with equal section can be readily provided.

Embodiment 2

The basic structure of an electromagnetic levitation type continuous metal casting apparatus according to the embodiment 2 is similar to that of the embodiment 1 (FIG. 4). The electromagnetic levitation type continuous metal casting apparatus according to the embodiment 2 comprises the molten metal storing furnace 2 for holding and storing the molten metal 1, the casting vessel 3 for upwardly receiving and holding the molten metal 1 in the form of molten metal column and for casting it in a predetermined size, the alternating electromagnetic field generation means 5 unified with the casting vessel 3 and disposed on the outer periphery thereof for generating an alternating electromagnetic field so as to electromagnetically and upwardly move the molten metal column which is received and held in the casting vessel 3, the alternating electromagnetic field generation means 5 being composed of a plurality of layers of coils, the heat exchange means 4 unified with the casting vessel 3 and disposed on the outer periphery thereof for causing a coolant to flow in the opposite direction of the molten metal column which is received and held in the casting vessel 3 and upwardly moved by the effect of the alternating electromagnetic field so as to cool and solidify the molten metal column, the tube shaped molten metal supplying path 7 for upwardly supplying the molten metal 1 to be cast from the molten metal storing furnace 2 into the casting vessel, and the high frequency heating means 8 disposed on the outer periphery of the tube shaped molten metal supplying path 7. The heat exchange means 4 according to the present embodiment is structured as shown

in FIG. 5 which is an enlarged sectional view. The heat exchange means 4 is unified with the casting vessel 3 and disposed on the outer periphery thereof, the casting vessel 3 being provided with a graphite liner layer 3a on the inner wall surface thereof, the flow of the coolant being inverted therein. Electromagnetic levitation coils 5a1 and 5a2 of the alternating electromagnetic field generation means 5 are extendly disposed over the outer periphery of the flow path of the coolant (heat exchange means) 4, namely the area where the flow of the coolant is inverted, the area of the alternating electromagnetic field generation means 5 being provided wider than that of the cooling means 4. On the inside of the electromagnetic levitation coils 5a1 and the 5a2 structuring the alternating electromagnetic field generation means 5 extended more downwardly than the area of the cooling means 4, a ceramic tube 3b structuring part of the casting vessel 3 is disposed. In more detail, the heat exchange means 4 is structured by a dual pipe so as to invert the flow of the coolant. At the portion 4a where the flow of the coolant is inverted, the electromagnetic levitation coil 5a2 which is the second layer from the lower end of the plurality of coils structuring the alternating electromagnetic field generation means 5 is disposed.

In the electromagnetic levitation type continuous metal casting apparatus in the aforementioned structure, by using the molten metal supplying path 7 composed of the graphite tube, a copper wire was continuously cast. As the result, a good wire product free of breakage and void could be obtained.

Since the mechanism of the cooling mechanism (heat exchange means) and the position of the alternating electromagnetic field generation means against the cooling mechanism is structured as described above, the solidification of the molten metal column starts at an area where the levitating force satisfactorily acts on the molten metal column. In other words, the molten metal column is solidified while the molten metal column and casting vessel are not contacted or they are contacted without a pressure. In addition, the molten metal is solidified while it is satisfactorily levitated and stirred. Thus, according to the aforementioned electromagnetic levitation type continuous metal casting apparatus, even in a continuous metal casting process or the like, cast products free of breakage can be stably obtained.

In the aforementioned structure, by providing the alternating electromagnetic field generation means 5 so that it can relatively moved along the cooling means 4 unified with the casting vessel 3 and disposed on the outer periphery thereof, various types of products can be cast.

In the present embodiment, a graphite was used as the tube shaped molten metal supplying path 7. However, in this embodiment, other electroconductive ceramics exemplified in the embodiment 1 can be used.

Embodiment 3

As shown by the outlined sectional view of FIG. 6, the electromagnetic levitation type continuous metal casting apparatus according to the embodiment 3 comprises the molten metal storing furnace 2 for holding and storing the molten

metal 1, the tube shaped cooling means 4 connected to a side surface of the molten metal storing furnace 2, and the casting vessel 3 for upwardly receiving and holding the molten metal 1 to be cast in the form of a molten metal column through the tube shaped molten metal supplying path 4 and for casting it in a predetermined size. The casting vessel 3 is also provided with the alternating electromagnetic field generation means unified with and disposed on the outer periphery thereof for generating an alternating electromagnetic field so as to electromagnetically and upwardly move the molten metal column which is received and held in the casting vessel 3, the alternating electromagnetic field generation means being composed of a plurality of layers of coils, and the cooling means unified with the casting vessel 3 and disposed on the outer periphery thereof for cooling and solidifying the molten metal column which is received and held in the casting vessel 3 and upwardly moved by the effect of the alternating electromagnetic field. The tube shaped molten metal supplying path 4 is provided with a high frequency heating means disposed on the outer periphery thereof. In addition, the molten metal storing furnace 2 is provided with a displacer 5 for pressuring the molten metal 1 which is held therein and for supplying the molten metal 1 into the casting vessel 3 through the cooling means 4. As shown in FIG. 7, when the displacer 5 is raised from the molten metal which is held in the molten metal storing furnace 2, the tube shaped molten metal supplying path 4 is projected nearly horizontally from the side wall of the molten metal storing furnace 2, and the

projecting position of the path 4 is over the liquid surface of the molten metal 1. The vertical section 4b connected to the casting vessel 3 is structured with as short length as possible. The molten metal storing furnace 2 is provided with a high frequency heating means on the peripheral wall thereof so as to keep the molten metal in molten state.

Then, by referring to FIG. 7, the operation and usage of the electromagnetic levitation type continuous metal casting apparatus according to the present embodiment will be described. The molten metal storing furnace 2, the casting vessel 3, and the molten metal supplying path 4 are prepared and set so as to perform a particular continuous metal casting operation. Thereafter, the displacer 5 is driven so that the alternating electromagnetic field generation means 5 is gradually submerged in the molten metal 1 of the molten metal storing furnace 2. By the submerging operation of the displacer 5, the liquid surface of the molten metal 1 is gradually raised. The raised molten metal is supplied to the casting vessel 3 through the molten metal supplying path 4 so as to perform the particular electromagnetic levitation type continuous metal casting operation. When the displacer 5 is lifted up due to the end or stop of the casting operation, the liquid surface of the molten metal 1 in the molten metal storing furnace 2 drops and the molten metal 1 in the molten metal supplying path 4 flows into the molten metal storing furnace 2 and is collected thereto.

As was described above, when the particular continuous metal casting operation is stopped, since the application of

the hydrostatic pressure by the molten metal 1 to the joints of the molten metal supplying path 4 and the like can be completely prevented, the problem of leakage of the molten metal 1 can be remarkably solved. On the other hand, with respect to the maintenance of the molten metal supplying path 4, since the molten metal 1 is collected to the molten metal storing furnace 2 and the molten metal supplying path 4 is extendedly disposed to a relatively high position of the molten metal storing furnace 2, it is not necessary to remove the molten metal 1.

As was described above, according to the electromagnetic levitation type continuous metal casting apparatus according to the present invention, when the casting operation is stopped, since the molten metal supplying path system for supplying the molten metal to be cast from the molten metal storing furnace to the casting vessel does not stores the molten metal, the maintenance of the molten metal supplying path becomes easy. In addition, since the molten metal supplying path does not have an intermediate connecting section, the probability of leakage of molten metal is reduced. In other words, when the casting operation is stopped, since the hydrostatic pressure by the molten metal is not applied to the molten metal supplying path system, the probability of leakage from joints can be remarkably reduced. Moreover, when the molten metal supplying path is replaced, the disposal of the molten metal in the molten metal storing path is not required. Consequently, according to the electromagnetic levitation type continuous metal casting

apparatus of the present invention, many advantages such as safe operation, easy maintenance, and high efficiency of molten metal in use can be practically obtained.

CLAIMS

1. An electromagnetic levitation type continuous metal casting apparatus comprising:

a molten metal storing furnace for holding and storing a molten metal;

a casting vessel for upwardly receiving and holding said molten metal in the form of a molten metal column;

cooling means unified with said casting vessel and disposed on the outer periphery thereof for cooling and solidifying said molten metal column which is upwardly moved by the effect of an alternating electromagnetic field;

alternating electromagnetic field generation means unified with said casting vessel and disposed on the outer periphery thereof for generating said alternating electromagnetic field, said alternating electromagnetic field electromagnetically and upwardly moving said molten metal column received and held in said casting vessel;

a tube shaped molten metal supplying path for supplying said molten metal to be cast from said molten metal storing furnace to said casting vessel; and

high frequency heating means disposed on the outer periphery of said tube shaped molten metal supplying path;

wherein said tube shaped molten metal supplying path comprises a horizontal section extended from said molten metal storing furnace and a vertical section disposed for upwardly supplying said molten metal into said casting vessel through a bend section, said bend section being provided with an appendix section horizontally disposed on an opposite side of

said molten metal storing furnace, said appendix section having high frequency heating means.

2. An electromagnetic levitation type continuous metal casting apparatus comprising:

a molten metal storing furnace for holding and storing a molten metal;

a casting vessel vertically disposed for upwardly receiving said molten metal in the form of a molten metal column;

cooling means unified with said casting vessel and disposed on the outer periphery thereof for causing a coolant to flow in the opposite direction of the moving direction of said molten metal column and for cooling and solidifying said molten metal column, said molten metal column being upwardly moved by the effect of an alternating electromagnetic field;

alternating electromagnetic field generation means unified with said casting vessel and disposed on the outer periphery thereof for generating said alternating electromagnetic field, said alternating electromagnetic field electromagnetically and upwardly moving said molten metal column received and held in said casting vessel, said alternating electromagnetic field generation means including a plurality of electromagnetic coils disposed on the outer periphery of said casting vessel;

a tube shaped molten metal supplying path for upwardly supplying said molten metal to be cast from said molten metal storing furnace into said casting vessel; and

high frequency heating means disposed on the outer

periphery of said tube shaped molten metal supplying path;

wherein said cooling means for causing said coolant to flow in the opposite direction of the moving direction of said molten metal column is structured so that the flow of said coolant is inverted in an area according to the second electromagnetic coil from the lower end of said plurality of electromagnetic coils.

3. The electromagnetic levitation type continuous metal casting apparatus as set forth in claim 2, wherein said cooling means includes a dual pipe.

4. An electromagnetic levitation type continuous metal casting apparatus comprising:

a molten metal storing furnace for holding and storing a molten metal;

a casting vessel vertically disposed for upwardly receiving and holding said molten metal in the form of a molten metal column;

cooling means unified with said casting vessel and disposed on the outer periphery thereof for cooling and solidifying said molten metal column which is upwardly moved by the effect of an alternating electromagnetic field;

alternating electromagnetic field generation means unified with said casting vessel and disposed on the outer periphery thereof for generating said alternating electromagnetic field, said alternating electromagnetic field electromagnetically and upwardly moving said molten metal column received and held in said casting vessel;

a tube shaped molten metal supplying path for upwardly

supplying molten metal to be cast from said molten metal storing furnace into said casting vessel;

high frequency heating means disposed on the outer periphery of said tube shaped molten metal supplying path; and

a displacer for pressuring said molten metal in said molten metal storing furnace and for supplying said molten metal into said casting furnace through said molten metal supplying path;

wherein said molten metal supplying path is extruded almost horizontally from a side wall of said molten metal storing furnace, the position of the extruded path being higher than the liquid surface of the molten metal when said displacer is raised from said molten metal in the molten metal storing furnace.

5. The electromagnetic levitation type continuous metal casting apparatus as set forth in claim 4, wherein said molten metal supplying path is composed of one body without intermediate joints.

6. The electromagnetic levitation type continuous metal casting apparatus as set forth in claim 4 or 5, wherein the height of a vertical section connected from said molten metal supplying path to said casting vessel through a bend section is small.

7. The electromagnetic levitation type continuous metal casting apparatus as set forth in claim 4 or 5, wherein a bend section connected from said molten metal supplying section to said casting vessel is provided with an appendix section extendedly disposed on the opposite side of said molten metal

storing furnace, said appendix section having high frequency heating means.

8. The electromagnetic levitation type continuous metal casting apparatus as set forth in Claim 1, wherein the electromagnetic generating means comprises a plurality of coils disposed on the periphery of the casting vessel and the cooling means causes the coolant to flow in the opposite direction to the molten metal and the coolant flow is inverted in an area corresponding to the second electromagnetic coil from the bottom.

9. The electromagnetic levitation type continuous metal casting apparatus as set forth in Claim 2 and further comprising displacement means for subjecting the molten metal in the furnace to pressure to cause the molten metal to flow along the supply path substantially horizontally from a side wall of the furnace and from a location higher than the level of the molten metal in the furnace with the displacement means raised from the molten metal.

10. Casting apparatus substantially as described with reference to any one or more of Figure 4, Figure 5 or Figures 6 and 7 of the accompanying drawings.

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